## PHYSICS 310/610 – Extragalactic Astronomy and Cosmology

Monday, Wednesday, and Friday 1:00-1:50, Olin 103

**Instructor:** Eric Carlson Office Hours

Office: 306 Olin Physical Laboratory Mon/Wed/Fri 11:45 – 12:45 and

My Web: <a href="http://users.wfu.edu/ecarlson">http://users.wfu.edu/ecarlson</a>
Tues/Thurs 12:00 – 2:00
or any time by appointment
e-mail: <a href="mailto:ecarlson@wfu.edu">ecarlson@wfu.edu</a>

**Remote:** Zoom Link generally used only with permission

**Texts:** Two are required

1. "Galaxies in the Universe, An Introduction" by Linda Sparke and John Gallagher, 2<sup>nd</sup> edition; available free online at link

https://ebookcentral.proguest.com/lib/wfu/reader.action?docID=307061

2. "An Introduction to Cosmology" by Barbara Ryden, Second Edition.

**Description:** This course covers two topics: The nature and organization of galaxies, and the nature, history, and future of the Universe as a whole. A wide variety of physics skills will be brought to bear. The course assumes a level of understanding of physics at the level of Modern Physics (Physics 215), though this material will be reviewed as needed. Often, more advanced concepts will come in as well (general relativity, particle physics, quantum mechanics, statistical mechanics), which will be discussed as needed throughout the course.

**Materials:** A scientific calculator is a necessity. At times a metric ruler may come in handy. A symbolic manipulation program like Maple is a good idea too.

**Covid and Attendance:** You are expected to follow all university regulations regarding precautions for Covid-19. To help minimize the spread of germs, if you have any symptoms of a communicable disease, **do not come to class**. Instead, email me and your absence will be considered excused (you don't need a doctor's note, unless it is a test date. You can attend via the **Zoom link**, or even view the recorded lectures later. There may be other reasons besides illness for missing class; you should check these in advance with me.

**Class Participation:** Class participation is encouraged, and counts towards your grade. If you don't understand something, ask me. If you don't ask me, I'll ask you, which can be embarrassing.

**Pandemic Plans**: If there is a catastrophic closure of the school, for any reason, we will attempt to continue class electronically. Check the website, your email, or try my cell phone.

**Exams:** There will be a midterm and a final. Both tests will include both quantitative and essay questions. You should bring a calculator on exam days. The midterm will be around **October 18**, and the final will be as scheduled on **Friday December 15** at 2:00. <u>If possible, I would like to schedule the midterm for two hours one evening in the middle of October.</u>

For undergraduates, there will often be a selection of questions for which one may be skipped; graduates will be required to do all questions and skip none of them

**Homework:** Homework will occur regularly, generally due on Wednesdays and Fridays. It is to be done and turned in at the start of each class period. Homework will normally be posted on the web at least one week before it is due. Twice during the semester, you may use a homework

pass (distributed by me) to give you a one class extension on the homework (it is still due). Homework turned in late (without a homework pass) will receive a 20% penalty per class day it is overdue.

Graduate students will typically have a single extra question on each homework which only graduate students are expected to do.

You should attempt to do the homework by yourself, but if you get stuck, you should feel free to talk to your friends in the class, or myself. In particular, you should feel free to check your final answers with your friends. You must ultimately understand and have performed all the calculations in your homework yourself, but I do not mind if others have helped you with it.

<b>Grading:</b> The two tables at
right are a not necessarily
accurate guess as to what my
grading scheme will be. In
particular, I reserve the right
to grade on a sliding scale.
For graduate students,

Grading Brea	<u>kdown</u>
Homework:	40%
Midterm:	20%
Class Part:	10%
Final:	30%
TOTAL:	100%

Grading S	Scale	
94% A	80% B-	67% D+
90% A-	77% C+	63% D
87% B+	73% C	60% D-
83% B	70% C-	<60% F

because there are no D grades, anything below 70% is an F.

World-Wide-Web: Materials for this course can be found on our home page at

## http://users.wfu.edu/ecarlson/cosmo2

This includes handouts, slides, homework and solutions, old tests, and links to recorded lectures.

## **Tentative Schedule:**

Aug/Sept 28 30	1	Introduction, star basics, stellar evolution
September 4 6	8	Giant stars and later stages, stellar clusters, geometric distance
September 11 13	15	Standard candle distances, Milky Way basics, the Disk
September 18 20	22	The bulge, nucleus, and halo, gravity and orbits, rotation, dark matter
September 25 27	29	Spiral arms, clusters, shapes of galaxies, galaxy classification
October 2 4	6	Galaxy collisions, active galaxies, galaxy clusters and superclusters
October 9 11		Hubble's law, Friedmann equations, review (Fall break)
October 16 <b>18</b>	20	review, Midterm, scale factor, expansion
October 23 25	27	General relativity, dark energy, the big bang, the CMBR
Oct/Nov 30 1	3	Matter and radiation eras, recombination, primordial nucleosynthesis
November 6 8	10	Particle physics, particles in the early universe
November 13 15	17	The early universe, inflation, origin of everything, structure formation
November 20		What is dark matter? {Thanksgiving break}
Nov/Dec 27 29	1	Baryogenesis, the fine-tuned universe, multiple universes
December 4 6	8	Cosmic eschatology, review
December	15	Final 2:00 PM